

Developing A Universal Model for Estimating Secchi Disk Depth from Landsat TM and ETM+ in Indonesian Lakes

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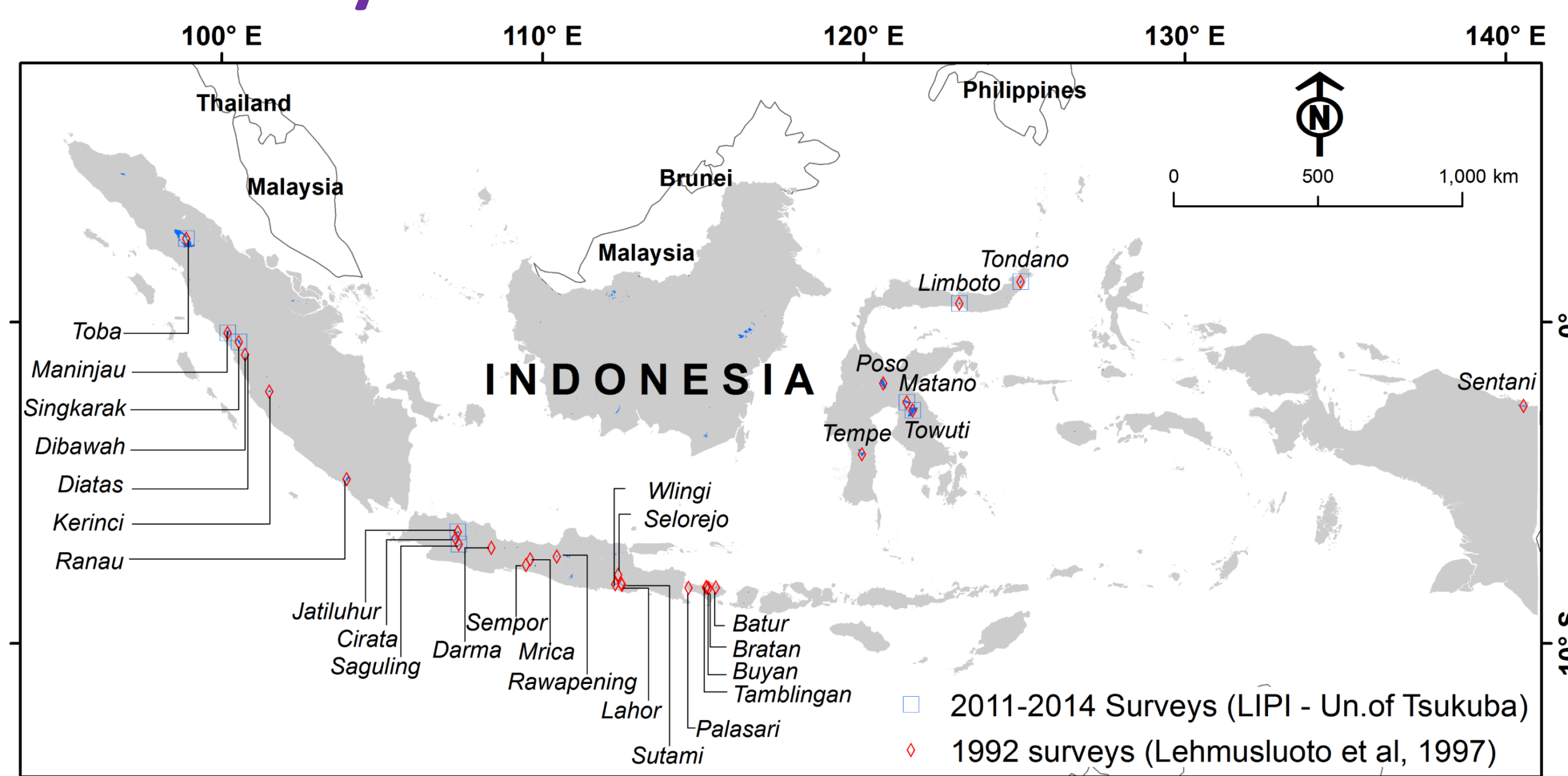
1. Introduction

- Monitoring data for evaluating water quality in Indonesian lakes are very limited.
- Combination of fields surveys and remote sensing can provide comprehensive lakes monitoring data.
- Several models has been developed to estimate Secchi Disk depth (SD) using Landsat TM imagery [1,2,3]. Existing models can not be directly applied, it is necessary to recalibrate the model using in-situ data.
- If the atmospheric effects can be removed in advance, a fix coefficients of SD estimation model can be universally applicable^[2].
- Lack of in-situ SD for model recalibration and ancillary data for atmospheric correction are the main problem for estimating SD from Landsat in Indonesian lakes.

2. Objective

- Propose atmospheric correction (AC) for Landsat TM imagery with out ancillary data
- Develop a Model for SD estimation which can be universally applicable for Indonesian lakes with out requirement for in-situ SD for recalibration.
- Generate long-term SD using the developed model for Lake Maninjau

3. Study area

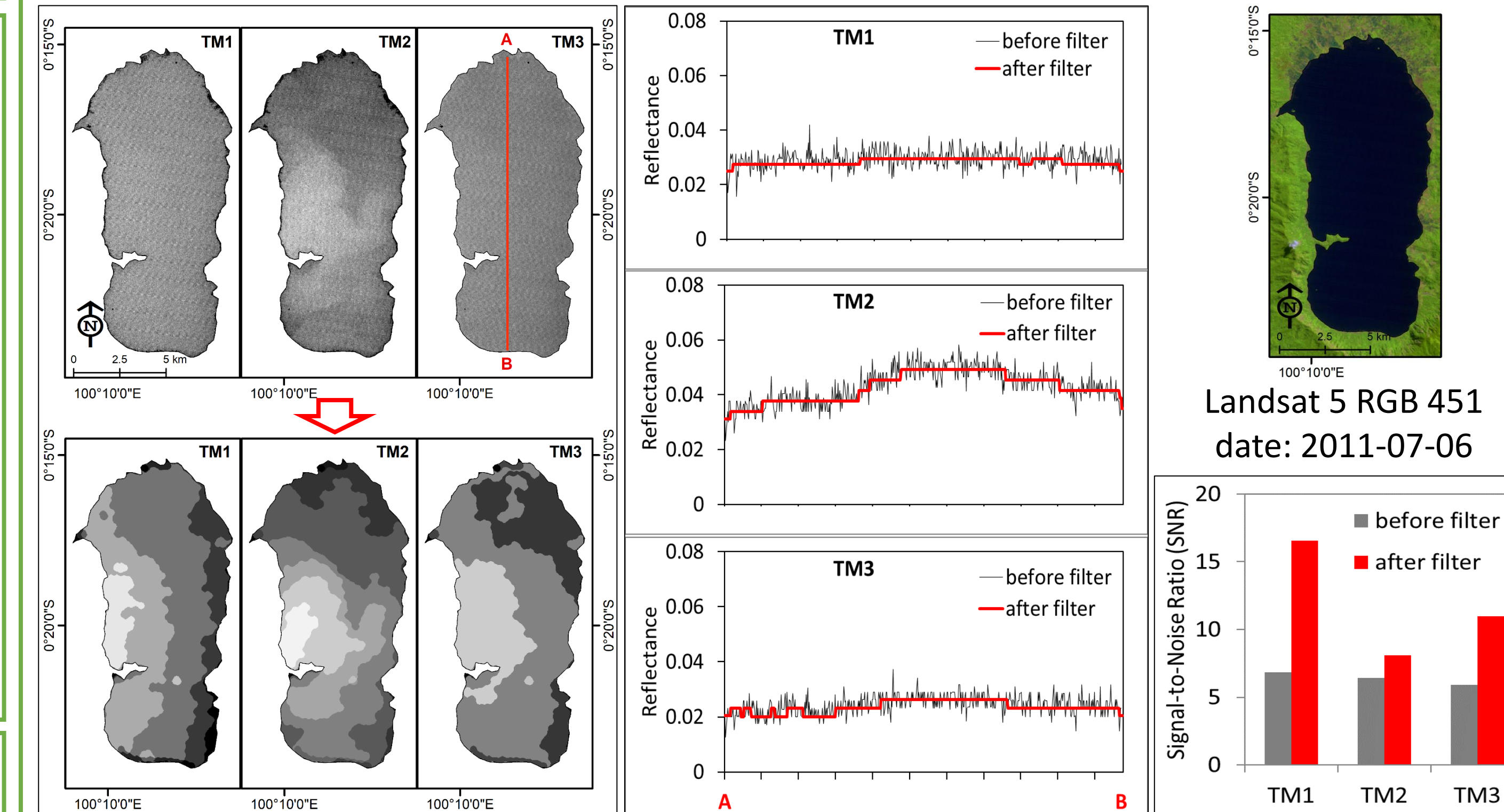


4. Method

- Apply iterative median filter to improve Signal-to-Noise Ratio (SNR) on Landsat Images
- Perform Atmospheric correction; (1)Rayleigh corr. using 6S code^[4] & (2) zero assumption at TM5 band
- Carried out multiple regression between the log-transformed in-situ SD & the corresponding pre-processed Landsat data to obtain model coefficients
- Test the developed model using in-situ data of 31 lakes (1992-1993)^[5]
- Select the best model & generate long-term SD for L. Maninjau & compare with in-situ SD (2001-2018)

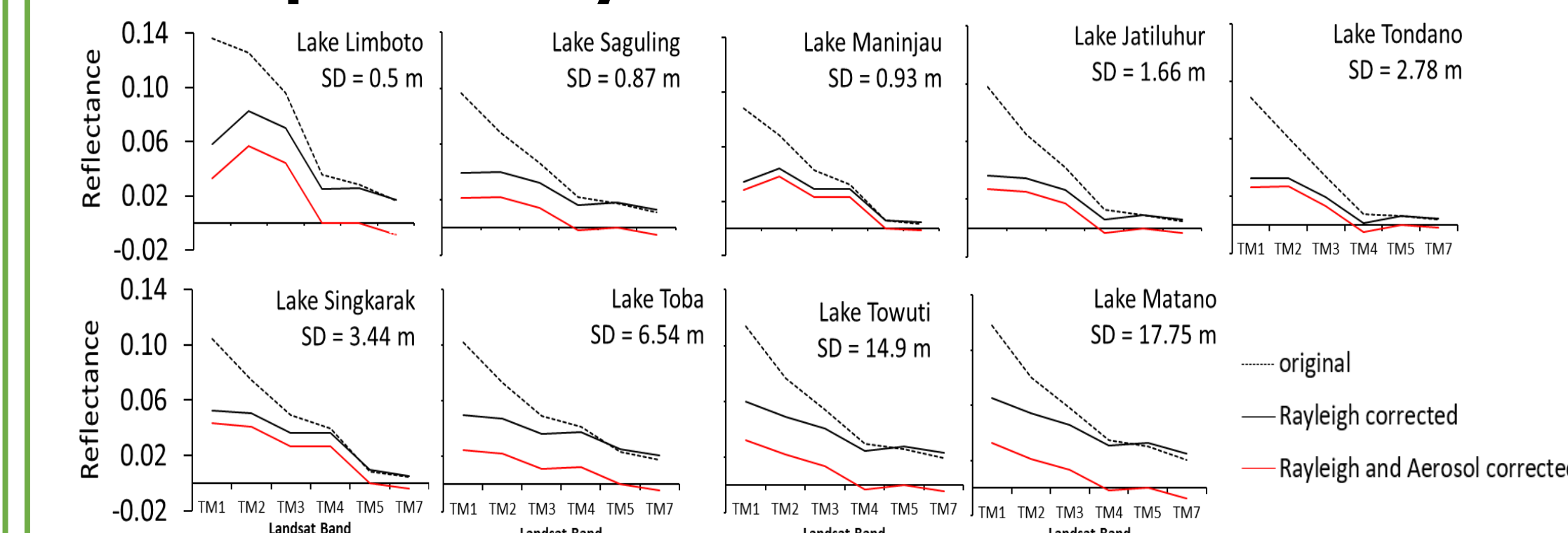
5. Result

Improved Signal-to-Noise of Landsat TM image



The effects of median filter in removing noise over the water surface and improvement of SNR on Landsat Visible bands, a case of Lake Maninjau.

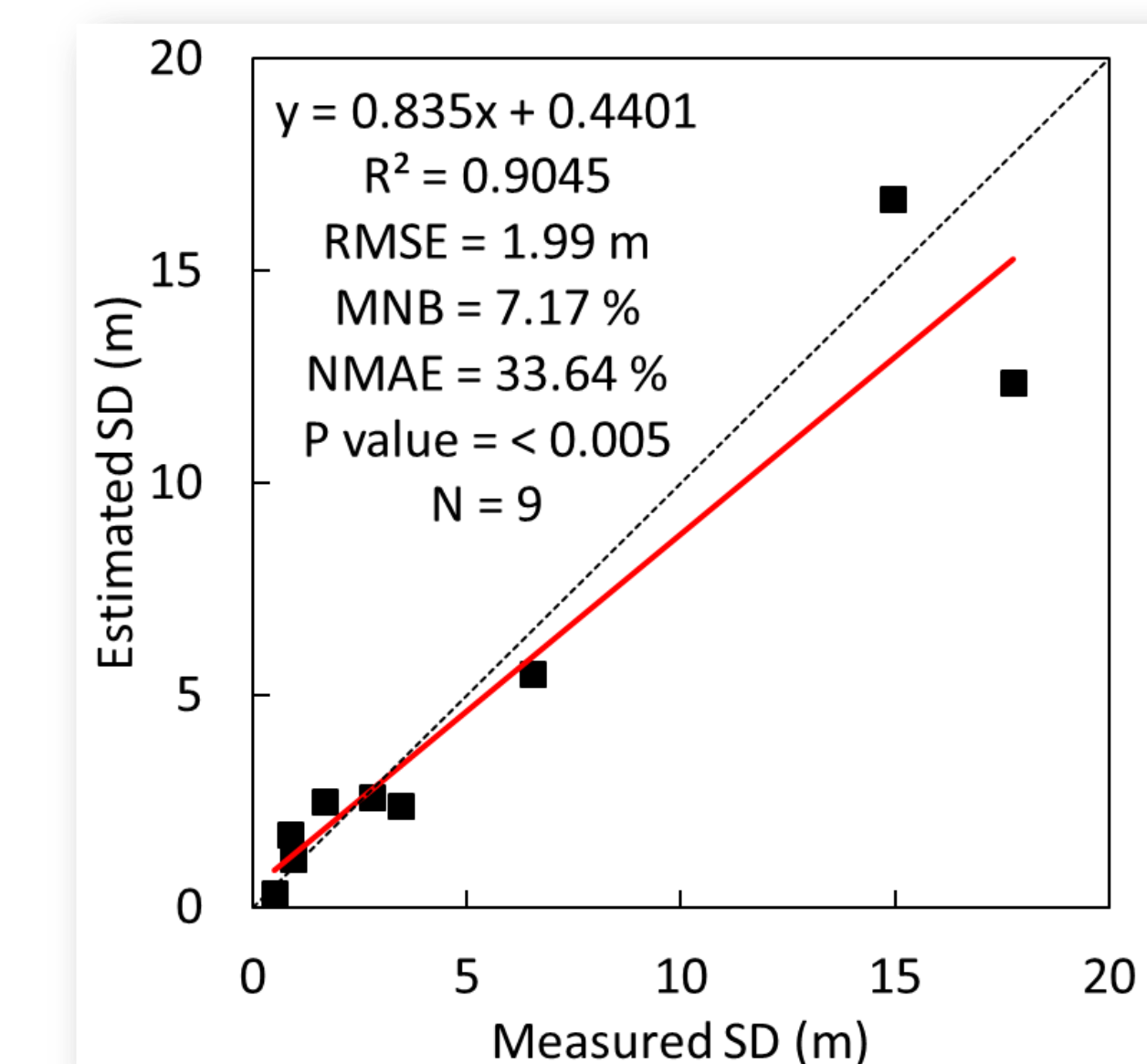
Atmospherically corrected reflectance



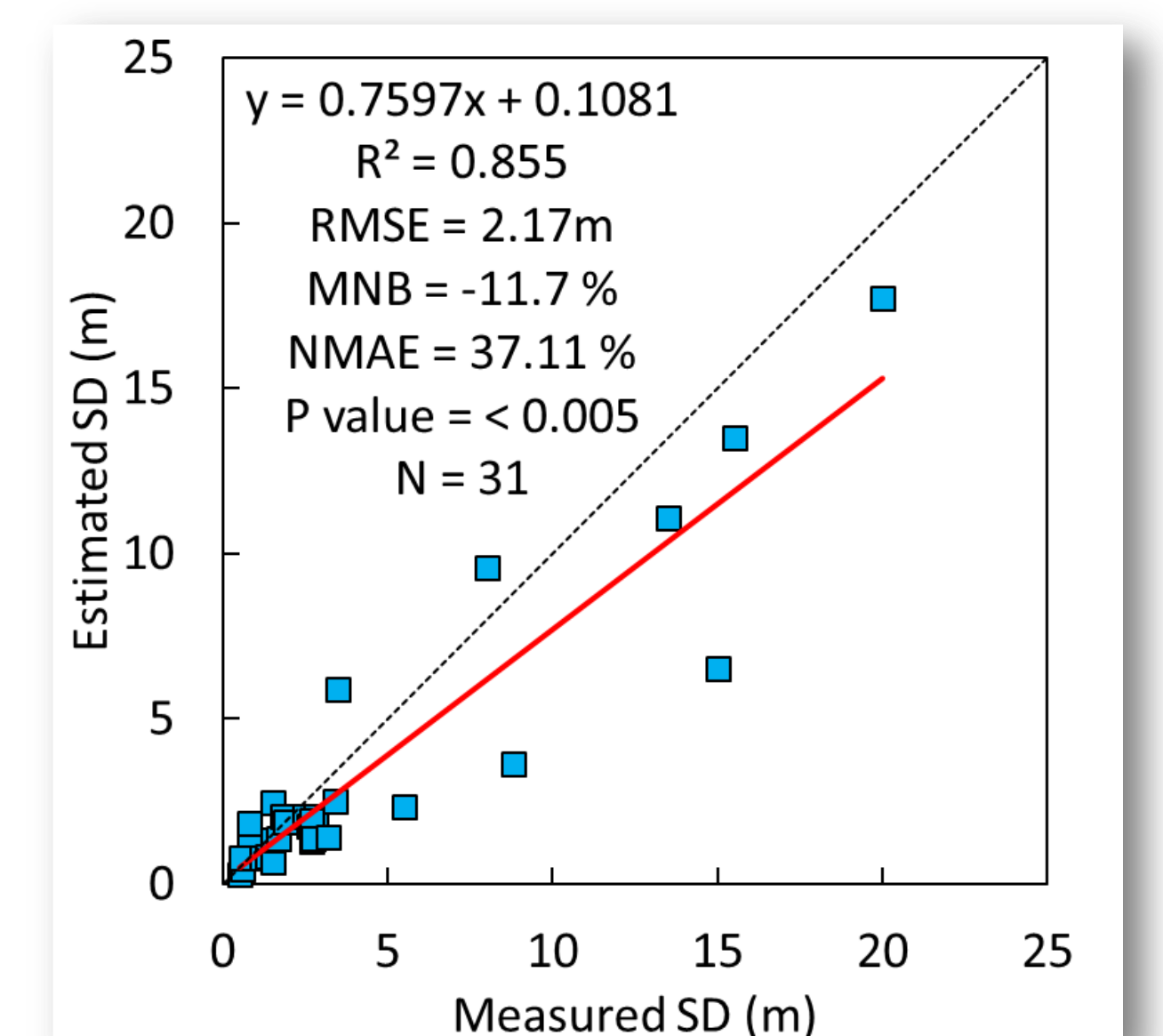
Reflectance spectra of top-of-atmosphere (TOA), after Rayleigh correction, and after aerosol effect mitigation in nine Indonesian lakes. After Rayleigh correction, the reflectance at TM band 5 were still observed, nevertheless using zero reflectance assumption at this band the shape and magnitude of spectra became reasonable. The final atmospherically corrected reflectance were used as the input for SD estimation.

Proposed model and the performance

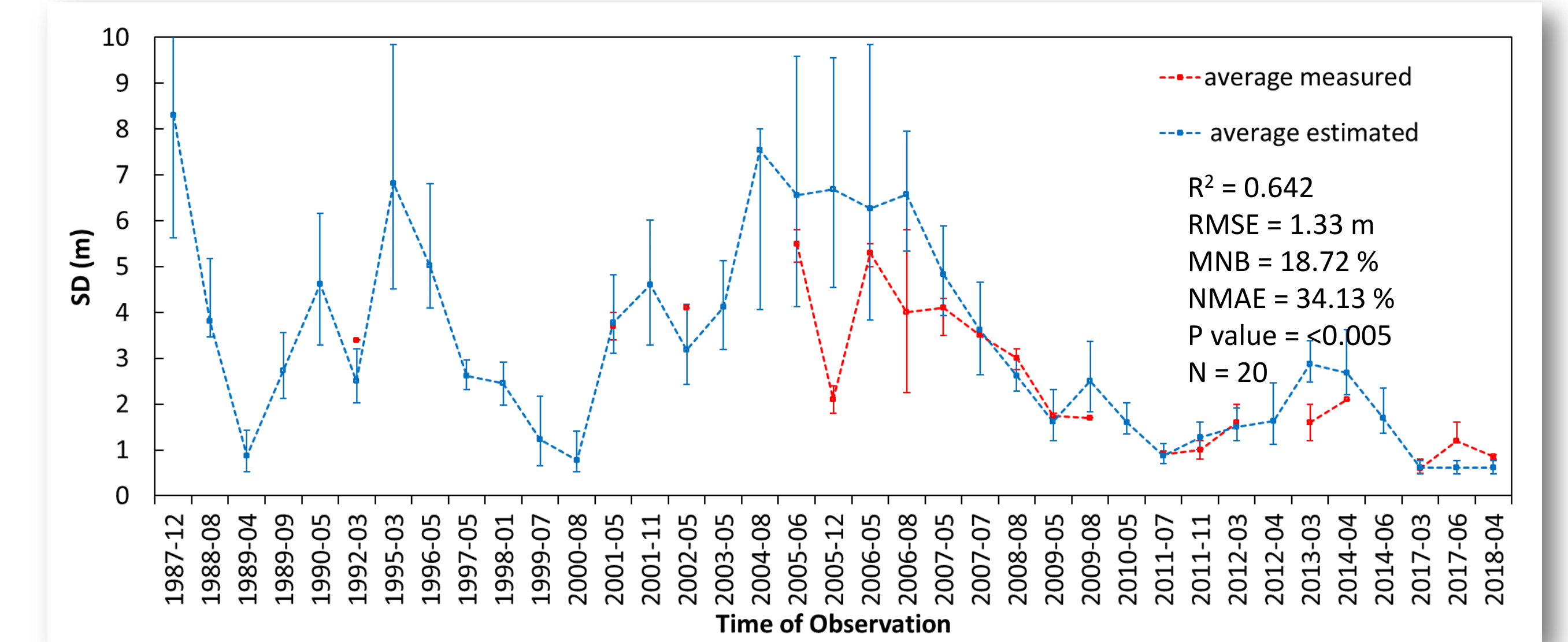
$$\ln SD = -0.78 + 3.54 \left(\frac{TM1}{TM2} \right) - 3.14 \left(\frac{TM3}{TM2} \right)$$



Model calibration



Model Validation on 31 lakes



Long-term SD of L. Maninjau generated from the model

6. Conclusion

- In-situ SD data of Indonesian lakes are very limited, however the proposed model for estimating SD involved $\left(\frac{TM1}{TM2} \right)$ & $\left(\frac{TM3}{TM2} \right)$ of pre-processed Landsat TM can provide reasonable result ($R^2 = 0.85$, $NMAE = 37.11\%$).
- The proposed model is simply applicable one & has potential to provide SD data for various lakes without the requirement of in-situ data for model recalibration.

References :

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 [2] Kloiber, S.M., Brezonik, P.L., Bauer, M.E.: Application of Landsat imagery to regional-scale assessment of lake clarity. Water Research Vol. 26, pp. 4330-4340, 2002
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 [4] <http://6s.ltdri.org/pages/run6SV.html>
 [5] Lehmusluoto, P., Machbub, B.: National Inventory of the major lakes and reservoirs in Indonesia. Exped. Indo-danau Tech. Report. pp.1-71, 1997.